

PCT/DE98/01186
Heiland

98HEL1149WOP

- 22 -

Claims

- Sub
BB
1. Imaging and/or raster-mode scanning apparatus,
in particular scanning microscope, having a
5 compensation device for compensating for ambient
influences that may degrade the imaging, comprising:
- an image acquisition device (7) for acquiring at
least one pixel of an object, and
 - an image processing device (2) which is connected
10 downstream of the image acquisition device, and
also an image display device, furthermore at least
 - an electrical filter (5),
 - a sensor (4) for picking up a first signal, and
 - an actuator and/or a control element (3),
- 15 characterized in that
the first signal dependent on the ambient influences
passes through the filter directly and drives an
actuator and/or a control element (3) which has an
effect on the imaging and/or on the image display, in
20 the calibrated state of the apparatus, which is
characterized by the setting of the transfer
characteristic of the filter, the image degradation is
greatly reduced or essentially compensated for, and
in that the filter (5), for calibrating the apparatus,
25 has a calibration input and a second signal is applied
to the calibration input of the filter.
2. Apparatus according to Claim 1,
characterized in that
the apparatus comprises at least one sensor (4) for
30 detecting at least one physical quantity outside the
apparatus, this sensor (4) outputting the first signal
which depends on the ambient influences at the location
of the sensor (4).
3. Apparatus according to Claim 2,
35 characterized in that

AMENDED SHEET

the sensor (4) comprises at least one pick-up for electromagnetic and/or magnetic fields and/or air vibrations and/or ground vibrations.

4. Apparatus according to Claim 1,
5 characterized in that
the signal input of the filter (5) is connected to an output of the image processing device (2).

5. Apparatus according to ^{Claim 1} ~~one of the preceding~~
~~claims,~~
10 characterized in that
the apparatus comprises a device for the manual calibration of the filter.

6. Apparatus according to ^{Claim 1} ~~one of the preceding~~
~~claims,~~
15 characterized in that
the control element (3) is arranged in the image processing device (2) and at least part of the image degradation is reduced or compensated for in the image processing device.

7. Apparatus according to ^{Claim 1} ~~one of the preceding~~
~~claims,~~
20 characterized in that
the actuator (3) is assigned to a scanning device of the apparatus.

8. Apparatus according to ^{Claim 1} ~~one of Claims 1 to 4, 6~~
~~or 7~~
25 characterized in that
an output of the image processing device (2) is connected to the calibration input of the filter (5).

9. Apparatus according to ^{Claim 1} ~~one of the preceding~~
~~claims,~~
30 characterized in that
the second signal varies as a function of a scanning position of the scanning device and/or of time.

10. Apparatus according to ^{Claim 2} ~~Claims 2 and 8,~~
35 characterized in that

AMENDED SHEET

the apparatus is designed for operation in a calibration mode and for subsequent operation in an image mode,

whereby, in the calibration mode, ambient influences which degrade the image are detected by the imaging of a predetermined reference object and comparison of the image with the real structure of the reference object in the image processing device, and are greatly reduced or essentially compensated for by calibration of the filter, and

whereby the image defects are compensated for by maintaining the calibration in the image mode, even in the event of a change in the ambient influences.

11. Apparatus according to Claim 10,
- 15 characterized in that in the calibration mode:
- a scanning device scans a selected section of a reference object,
 - the digital image processing device (2) compares a stored signal assigned to the reference object with the image signal of the reference object, the said image signal having been obtained from the image acquisition device (7), and forms a defect signal assigned to the difference and outputs it to the filter (5), and
 - 25 - the apparatus stores, in a memory, data for generating the second signal for setting the transfer parameters of the filter for the image mode.

12. Apparatus according to Claim 10,
- 30 characterized in that in the image mode:
- a scanning device scans the object to be imaged, and
 - the apparatus, taking the data stored during the calibration mode as the basis, generates the second signal for defining the transfer parameters of the filter.
- 35

AMENDED SHEET

9 13. Apparatus according to ^{Claim 2}~~Claims 2 and 8~~,
characterized in that
the apparatus is set up for automatically calibrating
the filter during the image mode.

5 14. Apparatus according to Claim 13,
characterized in that
the image acquisition device (7) scans the object to be
imaged and the image processing device (2) is set up
for determining a temporal displacement of line
10 centroids of successive image lines within the whole
image and outputs the second signal as a function of
this temporal displacement to the filter (5).

15 15. Apparatus according to Claim 13,
characterized in that
the image processing device is set up for determining
the temporal displacement of an image centroid of
successive images and outputs the second signal as a
function of this temporal displacement to the filter
(2).

q 20 16. Apparatus according to ^{Claim 13}~~one of Claims 13 to 15~~,
characterized in that
the filter is set up for carrying out the
cross-correlation of the first signal and of the second
signal.

q 25 17. Apparatus according to ^(Claim)~~one of the preceding~~
~~claims~~,
characterized in that
the apparatus is set up for reducing or compensating
for the image degradation by means of actuators and/or
30 control elements acting in two mutually orthogonal
directions.

q 18. Apparatus according to ^(Claim)~~one of the preceding~~
~~claims~~,
characterized in that
35 the apparatus comprises a scanning electron microscope,
a force microscope, a surface roughness measuring

AMENDED SHEET

instrument, an optical scanning microscope, a light microscope, a transmission electron microscope or a lithography installation.

19. Apparatus according to Claim 18,

5 characterized in that,

in the case of the electron microscope, the actuator (3) comprises a device for deflecting the electron beam and/or a device for displacing the sample.

20. Apparatus according to Claim 18,

10 characterized in that,

in the case of the light microscope, the actuator (3) comprises a device for deflecting the light and/or a device for displacing the sample.

21. Apparatus according to ^{claim 4} ~~Claims 4, 8 and 15,~~

15 characterized in that

the apparatus is a light microscope or a transmission electron microscope, the first signal also being determined from the temporal displacement that is determined.

22. Method for operating an imaging and/or raster-mode scanning apparatus for compensating for ambient influences that may degrade the imaging, in particular for operating an apparatus according to ^{claim 1} ~~one of the preceding claims 1 to 21,~~

25 a first signal dependent on the ambient influences being passed directly through an electrical filter (5) and the output signal of the filter driving an actuator and/or a control element (3) which has an effect on the imaging and/or the image display, whereby, in the
30 calibrated state of the apparatus, which is effected by setting a transfer characteristic of the filter, given by transfer parameters, the image degradation is greatly reduced or essentially compensated for, and the calibration of the apparatus is carried out by the
35 setting of the filter (5) by a second signal being applied to the calibration input of the filter.

AMENDED SHEET

23. Method according to Claim 22,
characterized in that
the calibration of the apparatus is carried out by
manual setting of the filter (5).

5 24. Method according to Claim 22,
characterized in that
a control element (3) in the image processing device
(2) is driven and the compensation of the image
degradation is carried out at least partially in the
10 image processing device.

25. Method according to Claim 22,
characterized in that
an actuator (3) in the scanning apparatus is driven and
the compensation of the image degradation is carried
15 out at least partially by driving the actuator (3) of
the scanning apparatus.

26. Method according to Claim 22,
characterized in that
the apparatus is operated in a calibration mode and
20 subsequently in an image mode, whereby

- ambient influences that degrade the imaging are
detected by means of a sensor (4) which is
arranged outside the apparatus and drives the
signal input of a filter (5),

25 - in the calibration mode, the degradation of the
image is greatly reduced or essentially
compensated for by the imaging of a predetermined
reference object and comparison of the image with
the real structure of the reference object and by
30 calibration of the transfer characteristic of the
filter, and

- in the image mode, the degradation of the image is
at least partially compensated for by maintaining
the calibration, even in the event of a change in
35 the ambient influences.

27. Method according to Claim 26,

AMENDED SHEET

characterized in that
the calibration mode comprises at least the following
steps:

- 5 - determination of a first signal which depends on
the interfering influence at the location of the
sensor, by a sensor (5) arranged outside the
apparatus;
- application of the first signal to the signal
input of the filter;
- 10 - acquisition of a selected section (9) of a
predetermined reference object by means of an
image acquisition device (7) by the scanning of
the reference object;
- comparison of the acquired image with the real
15 structure of the reference object; and
- determination of a defect signal assigned to the
difference;
- application of the second signal, derived from the
defect signal, to the regulating input of the
20 filter (5) for defining the transfer
characteristic of the filter;
- application of the output signal of the filter to
the signal input of a regulating amplifier (6)
- application of the output signal of the regulating
25 amplifier to an actuator and/or a control element
(3) for the purpose of correcting the reduced
image quality;
- iterative calibration of the transfer
characteristic, in such a way that the reduction
30 of the imaging quality is greatly reduced or
essentially compensated for, by means of the
following steps:
 - comparison of the corrected image with the real
structure of the reference object
 - 35 - alteration of the transfer characteristic of
the filter in such a way that the corrected

AMENDED SHEET

image approximates to the real structure of the reference object

- storage of data for generating the determined transfer characteristic of the filter for the image mode.

28. Method according to Claim 26, characterized in that,

in the image mode, a sample is acquired by scanning, the transfer characteristic of the filter of the apparatus that has been determined in the calibration mode being fixedly prescribed, and the output signal of the digital filter, after passing through a regulating amplifier (6), is assigned to the actuator and/or the control element (3), with the result that image defects are greatly reduced or essentially compensated for even in the event of a change in the ambient influences.

29. Method according to Claim 22, characterized in that

- ambient influences which impair the imaging are detected by means of a sensor (3), which is arranged outside the apparatus and drives the signal input of a digital filter (5) with a first signal,
- an image acquisition device feeds an image processing device (2), in which an image analysis is carried out and a signal dependent on the analysis is applied as the second signal to the calibration input of the filter,
- the output of the filter is applied via a regulating amplifier (6) to an actuator and/or a control element (3) of the apparatus, which has an effect on the image, the image degradation thereby being greatly reduced or essentially compensated for.

30. Method according to Claim 29, characterized in that

AMENDED SHEET

- Sub B3 Cont.
- the object to be imaged is scanned by the image acquisition device,
 - the image analysis comprises the recursive determination of the displacement of the line centroids of successive image lines within the whole image, and
 - the second signal is calculated from this temporal displacement.

31. Method according to Claim 29,
characterized in that

- the image analysis comprises the recursive determination of the displacement of the image centroid of successive images, and
- the second signal is calculated from this temporal displacement.

32. Method according to ^{Claim 30} ~~either of Claims 30 or 31~~,
characterized in that
essentially the cross-correlation of the first signal with the second signal is carried out in the filter (5) and, consequently, the actuator or the control element (3) is fed with a drive signal which is dependent on the cross-correlation between the first signal and second signal.

33. Method according to ^{Claim 21} ~~either of Claims 21 or 22~~,
characterized in that

- an image acquisition device feeds an image processing device (2),
- an image analysis is carried out in the image processing device, and
- a signal dependent on the image analysis is applied as the first signal to the signal input of the filter, and
- a signal dependent on the image analysis is applied as the second signal to the calibration input of the filter,

Sub 93
any.

5 - the output of the filter (5) is applied via a regulating amplifier (6) to at least one actuator and/or one control element (3) of the apparatus, which has an effect on the imaging, the imaging degradation thereby being greatly reduced or essentially compensated for.

34. Method according to Claim 33, characterized in that the image analysis comprises the recursive
10 determination of the displacement of the line centroids of successive image lines within the whole image or the recursive determination of the displacement of the image centroid of successive images.

9
a 15 ~~35. Method according to one of the preceding method claims,~~

characterized in that the image degradation is essentially compensated for by means of actuators and/or control elements acting in two mutually orthogonal directions.

20 36. Apparatus for compensating for ambient influences in imaging and/or raster-mode scanning apparatuses that may degrade the imaging, comprising:

- a calibratable digital electrical filter (5);
- a regulating amplifier (6) which is electrically
25 connected downstream of the filter,
- an actuator and/or control element (3) driven by the regulating amplifier,

characterized in that
a first signal dependent on the ambient influences can
30 be passed via the signal input of the filter directly through the latter, and
a second signal is applied to the calibration input of the filter, and
the driven actuator and/or the driven control element
35 (3) has an effect on the image,

whereby, in the calibrated state of the filter, the image degradation is greatly reduced or essentially compensated for.

37. Apparatus according to Claim 36,

5 characterized in that

the apparatus comprises at least one sensor (4) for detecting at least one physical quantity outside the apparatus, this sensor outputting the first signal which is dependent on the ambient influences at the

10 location of the sensor.

add A' >

AMENDED SHEET